Fermi National Accelerator Laboratory

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Top Search in the High P_T Dilepton Channel at CDF

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ABSTRACT

A standard model $t\bar{t}$ pair decays into high transverse momentum (P_T) dileptons (e or μ) with a branching ratio of 4/81. Top search in this channel has the advantage of a very clean signature and a low background rate, especially in the $e\mu$ channel. CDF has searched for top quark in this channel along with other decay channels during the 88/89 run, which had a total luminosity of 4.1 pb^{-1}. A lower top mass limit of 91 GeV was obtained. The current CDF data taking run is expected to yield a total luminosity of 25 pb^{-1}. In this talk, a summary of CDF's top search in this channel from the previous run as well as the current status at CDF will be presented.

1. Introduction

1.1. Top production and decay at the Tevatron energy

At $\sqrt{s} = 1.8$ TeV, the dominant process for top production is $p\bar{p} \to t\bar{t}$. In the Standard Model (SM), the top decay is mediated via weak charged current, i.e., $t \to Wb$. The current lower limit on the top mass is 91 GeV, obtained by the CDF collaboration during the 88/89 data taking run.[1] Therefore, the W produced in top decays are real. Based on the SM W decay branching ratios, one expects the total branching fraction for $t\bar{t}$ decays semileptonically to high P_T dileptons (e or μ) is 4/81. This does not include dileptons from $t \to \tau \to e$ or μ decays, which contributes to about 10% of the dilepton signal. Top search in the high P_T dilepton channels has many advantages. The high P_T isolated leptons are easily triggered and detected at a collider. The singals from W's and Z's will provide many important calibrations and efficiency factors. The background in this channel is relatively low and can be rejected with topology cuts. With enhanced B-tagging ability by introducing a silicon vertex detector for the 1992 run, CDF stands to improve the top signal in this channel much further.

1.2. The CDF detector for 1992 run

The CDF detector for the 88/89 run is well documented.[1] Here we just briefly describe the new and modified detector components. For the 1992-1993 run, two new muon system have been added. One overlaps with the existing central muon (CMU) system with a steel wall of 60cm thickness (about 2 interaction length λ). This brings the total materials for muons between pseudo-rapidity (η) 0.1 and 0.4 to about 7λ. Another muon system extends the coverage of CMU from $\eta = 0.63$ to 0.9. A silicon vertex detector (SVX) is first implemented at CDF. The SVX has 2 barrels, each with 4 layers of silicon strip detectors. The position resolution is studied to be

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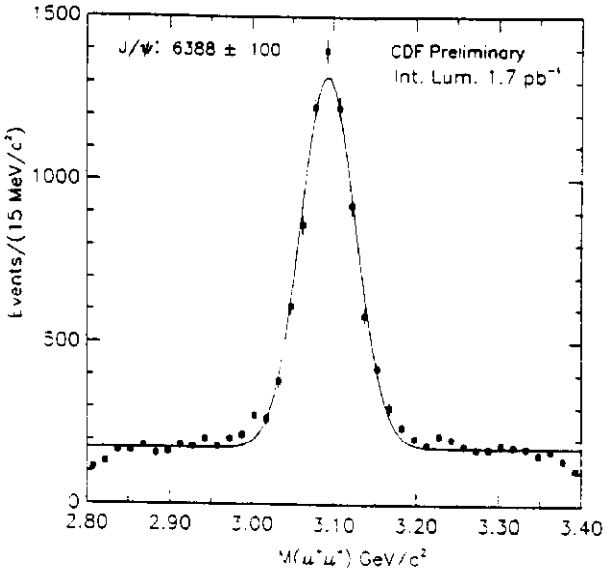

Figure 1: Low P_T dimuon invariant mass in the J/Ψ region

better than 12 microns. The SVX covers about 2/3 of the long interaction region. A new time projection vertex detector is also installed to replace the old detector. The end-plug calorimeter has been improved for better electron identification and triggering between $\eta = 1.1$ and 2.4. A new pre-shower detector is installed before the central calorimeter.

2. 1992 data (J/Ψ, W, Z)

The 1992-93 run is currently in progress. CDF has accumulated about 1.9 pb^{-1} as of writing. In this data sample, clean signals for J/Ψ, W and Z production has been studied. The J/Ψ acceptance is improved by a factor of 5 compare to the previous run, thanks to the lower trigger threshold and the new muon systems. A non-constraint low P_T di-muon invariant mass distribution in the J/Ψ mass region is shown in figure 1.

The W's and Z's are important not only for checking the working conditions of the detector, they are also very useful in determining the top detection efficiencies and for background studies. Figure 2 shows the W transverse mass and Z invariant mass distributions in both the electron and muon channels. The electron channel includes only the central calorimeters for the W's, while for Z's, the 2nd electrons can be in the plug. The muon tracks have been constrained to the colliding beam position in order to improve the momentum resolution. This is a preliminary result. No systematic corrections have been applied.

3. Detection efficiencies and background rejection

The detection efficiencies for high P_T leptons have been studied using the 88/89 data.[1] The over all efficiency for a 90 GeV top is about 0.8%. This means, if the top mass is 90 GeV ($\sigma = 150$ pb), 64 events will be expected in the high P_T

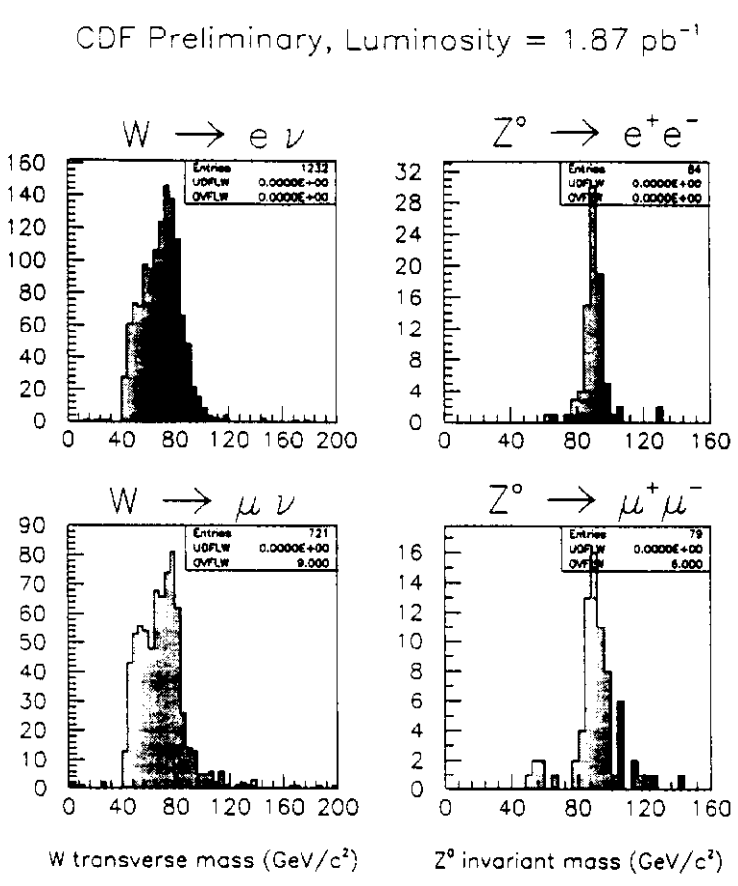

Figure 2: W transverse mass and Z invariant mass distributions from 1992 data

dilepton channel at CDF for an integrated luminosity of 25 pb^{-1}. The efficiency for higher top masses will be higher. The new CDF detector will also increase this efficiency factor. A conservative estimate based on this efficieny factor enables CDF to reach a top mass of about 130 GeV with 25 pb^{-1} in the dilepton channel.

4. Prospects for the 1992 run

For the current run, an integrated luminosity ~ 25 pb^{-1} is expected. With the added B-tagging power by the SVX, some new search channels are available for $t\bar{t}$ decay to dileptons. One example is to look for an identified lepton, another high P_T track and a displaced vertex in the SVX. Since some leptons may fall into the inactive region of the detector or may just fail the lepton identification cuts, this search channel is expected to improve the acceptance for top decays into dileptons.

As accumulated luminosity rises, we are entering heavier top mass region, which leads to higher detection efficiencies. With 25 pb^{-1}, combining with all available searching channels, a 150 GeV top quark is within CDF's reach.

5. References

1. F. Abe et al. (the CDF Collaboration), *Phys. Rev.* **D45** (1992) 3921.